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ABSTRACT

The work described in this paper was undertaken to study children's ability to preserve semantic relations during analogical mappings. Two experiments are described based on the understanding that metaphors and analogies are mappings from one semantic region (the domain of origin) to another (the range of application), which convey the idea that certain semantic relationships in the domain exist in the range. In the first experiment, ten preschool children, ten first-grade children and ten college sophomores were asked to map body-parts (domain) onto trees and mountains (range objects) using both connected and discrete modes of mapping. Children generally performed as well as the adults indicating that basic analogical ability is well developed in preschool children. The tasks and procedures in the second experiment were like those in the first one but the subjects were eight children aged 7-9 and eight university students. Again, the children performed as well as the adults and there is no evident developmental trend. It is concluded that the ability to perceive similar relationships between different entities is present early in language develoment. The only significant developmental change is in the area of creative speech, that is, the ability to avoid familiar comparisons and to map simultaneously many different relationships. (AMH)

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IF A TREE HAD A KNEE, WHERE WOULD IT BE? CHILDREN'S PERFORMANCE ON SIMPLE SPATIAL METAPHORS

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This research is concerned with the development of metaphorical ability, conceived of as the ability to preserve conceptual relationships across changes in actual content. This view of metaphorical ability does not distinguish between analogy, metaphor and simile, but focusses rather on what I believe to be their common core. I define a metaphor or analogy as a mapping from one semantic region (the domain of origin) to another (the range of application) which conveys that certain semantic or conceptual relationships present in the domain are present in the range also. Further details of this model and of Experiment 1 are reported in Gentner (in press).

The development of metaphorical ability is not well understood. The spontaneous speech of preschool children is full of seemingly metaphorical remarks. For example, a two-year-old says "Oh Mommie! How balloonie your legs are!" or (when undressed) "I'm barefoot all over." (Chukovsky, 1968). It appears that not all these extensions arise from errors in the child's word meanings (cf Thomson & Chapman, 1975).

However, in experimental tasks designed to measure metaphorical ability preschool children acquit themselves rather poorly. Typical tasks used are interpretation of metaphors, such as "Can a person be soft?" (Asch and Nerlove, 1960); or choosing among possible metaphorical and nonmetaphorical completions for completing sentences such as "Look at that boy standing over there. He looks as gigantic as ..." (Gardner, Kircher, Winner & Perkins, 1974); or matching sentences and pictures (Kogan, 1975). Performance on these tasks rises fairly steadily with age until adolescence. These results seem to indicate that metaphorical ability develops after the acquisition of basic language skills.

The laboratory result that preschool children are poor at metaphor is at odds with the observation that novel comparisons are very common in their spontaneous speech. On closer examination, however, it appears that factors other then metaphorical ability are measured in these studies. One important factor is the children's conceptual knowledge, or lack of knowledge, of the domain from which the metaphor is taken and of the domain in which it is applied. For example, if young children do not know the culturally agreed-upon systems of personality traits and emotional states underlying the application of such metaphors as "hard/soft" or "sweet/bitter" to people, then their inappropriate use of such metaphors tells us nothing about their metaphorical ability per se. A second important factor is children's understanding of the nature of the task. Young children given a question like "Can a person be

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sweet?" may be more likely than older children to assume that their literal knowledge of word meaning is being called into question, and to respond literally even if they are capable of metaphorical responding. Finally, the subjective judgements of subjects' responses used in much of the previous work (such as "metaphorical/literal/thematic" or "appropriate/inappropriate ") allow adult-centered bias, in the absence of clear criteria for appropriate metaphor.

What is needed is a model of metaphorical thinking. Verbrugge (1975) has discussed metaphor and analogy in terms of a three-part division: the topic, the vehicle to which the topic is compared, and the ground, or shared resemblance between topic and vehicle. He has found evidence that the ground - the set of implicit commonalities - plays an important role in memory for metaphors and analogies (Verbrugge, 1975; Verbrugge & McCarrell, 1973). The work presented here is based on a similar but more detailed analysis: that metaphors and analogies are mappings from one semantic region (the domain of origin) to another (the range of application), which convey that certain semantic relationships in the domain exist in the range. This set of identical semantic relationships constitutes the ground - the similarity between the two things being compared. According to this analysis, a single metaphorical utterance can simultaneously convey several different similarities between the domain and the range. Generally, the more concepts an analogy or metaphor maps from domain onto range, the better it is thought to be. However the mapping must be internally consistent: the relations mapped from the domain must be applicable in the range without contradiction.

The present work focusses on this ability to preserve semantic relations during analogical mappings. The tasks were designed to avoid non-metaphorical confusions. A class of spatial analogies was chosen such that all three aspects - the domain, the range, and the relevent relational system - were familiar to preschool children, and the nature of the task was made very clear. Subjects were asked to map from the domain, a human body, to the range, a pictured concrete object. For example, a child was shown a picture of a mountain and asked, "If the mountain had a knee, where would it be?" The child responded by pointing to some point on the picture. After several different body parts had been mapped onto mountains, the child's responses were combined and a measure of consistency was computed. The set of body parts is connected by a set of transitive vertical relations as shown in Figure 1: the head is above the shoulders, the shoulders above the stomach, and so on. These relations should be preserved in a good analogy. Thus, the number of vertical reversals in the range (the mountain) was the measure of performance; the lower the number of reversals, the better the performance. An example of a reversal is mapping head below shoulders.

In pilot experiments, four-year-old children performed well. Therefore, in Experiment 1, two fairly difficult mapping tasks were used. In the Orientation task, the orientation of the range picture was varied: trees were shown right-side up, upside-down, or horizontal. Correct performance required the equivalent of a mental rotation in order to map the

Figure 1. The set of vertical relationships.

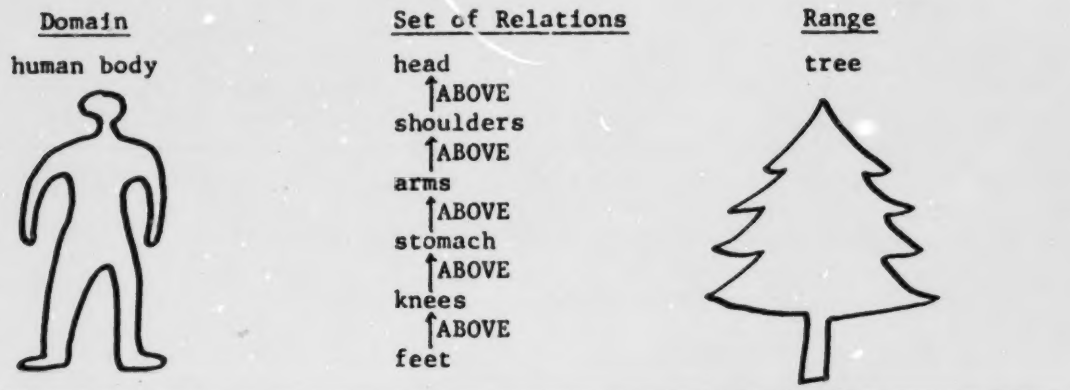
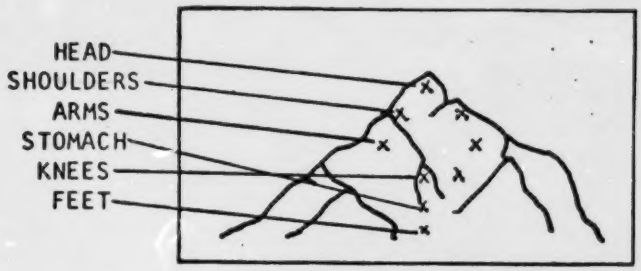


Figure 2. Connected and discrete modes of mapping.

a. Connected mode, showing one error (stomach reversed with knees).

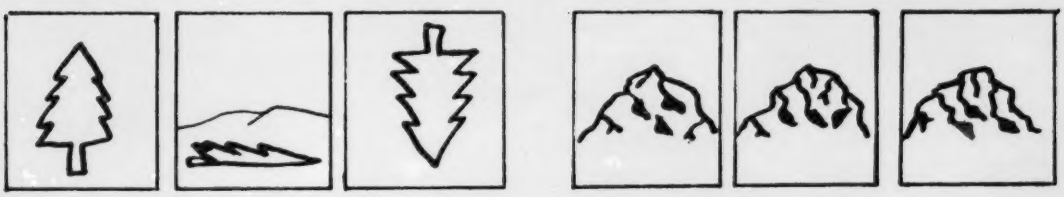


b. Discrete mode. (A total of six pictures is required.)

Figure 3. Sample pictures.

a. Orientation task

b. Local-features task



terms consistently with respect to the vertical axis of the tree, and not the axis of the picture. In the Local-features task, misleading local details were added to pictures of mountains. Subjects had to map face-parts onto mountains which had feature-like crags in any of the following configurations: eyes above mouth, eyes on the same level as mouth, or eyes below mouth. Correct performance required that the eyes be placed above the mouth, regardless of the configuration of features in the picture. The subject had to disregard the local details and to preserve the correct spatial relationship between eyes and mouth.

Experiment 1

Method

Subjects The subjects were 10 preschool children, aged 4/4 to 5/2; 10 first-grade children, aged 6/7 to 7/1; and 10 college sophomores at the University of Washington.

Tasks In the Orientation task, subjects had to map six body-parts --head, shoulders, arms, stomach, knees, and feet--onto trees in either upright, horizontal, or upside-down orientation with respect to the subject. Two modes of mapping were used: connected mode, in which all six body-part terms were mapped onto one picture, and discrete mode, in which the six terms were mapped one at a time onto six separate pictures. (See Figure 2). The design was age (3 levels) X orientation (3 levels) X mode of mapping (2 levels).

In the Local-features task, subjects were required to map two face-parts--eyes and mouth--onto mountains drawn with eyelike details either above, below or on a level with a mouthlike detail. Only the discrete mode was used: subjects mapped only one term for each picture. There were two nearly identical examples of each feature configuration; on one of these the eyes were mapped, and on the other the mouth was mapped. These two mappings were compared to yield a single measure of the relative vertical positions of eyes and mouth. The design was age (3 levels) X configuration (3 levels).

Materials There were 37 pictures: seven trees in each of three orientations, two mountains in each of three feature configurations and ten filler pictures of animals, shown in random order. Figure 3 shows sample pictures.

Procedure Subjects were asked "If this (range object) had a (domain part), where would it be?" Children were tested individually and responded by pointing to the picture, which the experimenter marked as indicated by the child. Adults were tested in groups of about six and marked their own pictures, which were presented in booklets, with the part to be mapped printed in the corner of each picture.

The basic data was simply the height of each body-part point from the base of the pictured object, recorded as a proportion of the overall height of the object. Measuring was done with a ruler, and interjudge agreement was high. All the heights for a given mapping (e.g., body

onto tree) were compared to yield the number of vertical reversals, ie. the number of instances in which two body parts were mapped in the wrong vertical order; eg. shoulders below stomach.

Results

Table 1 shows the mean number of reversals across age in the Orientation task. All groups performed well, averaging from .6 to .9 reversals per mapping, out of a possible 15 reversals. There were no significant effects of age. All groups performed better in connected mode than in discrete mode. ($F(1,27) = 29.1$, $p<.01$); this mode-of-mapping effect did not interact significantly with age. That all age groups experienced this difference in difficulty is reassuring; at least the task was not trivially simple. The only significant interaction was that of age by orientation ($F(4,54) = 2.7$, $p<.05$). This interaction apparently reflects the fact that, while both groups of children made fewer reversals than adults in the two non-vertical orientations, pre-schoolers made larger numbers of reversal errors than adults in the standard upright orientation.

Table 2 shows the mean number of reversals in the Local-features task, by age. Adults made more errors than children in this task. There was a significant age difference ($F(2,27) = 5.7$, $p<.01$); and a post hoc Scheffé test showed that the adult group made significantly more ties and reversals than the two groups of children, whose scores did not differ significantly from each other. Adults seemed to be more influenced than children by the configurations of local-features. Comparing subjects' use of all details present in the pictures confirmed adults' greater use of details. Out of 60 individual mappings performed by each age group, 59 of the adult mappings involved pointing to one or more details, as compared with 17 for first-graders and 7 for pre-schoolers.

Discussion

In this task, the children were familiar with the conceptual domains, and the phrasing of the question makes it clear that the child is to use an analogical interpretation. Further, there is an objection criterion for level of performance. Under these conditions, both groups of children performed extremely well. In the Orientation task, there were no significant age differences between pre-schoolers, first-graders, and adults. In the Local-features task, children performed better than adults. The adult performance in this task could be seen as an indicating relative inability to preserve abstract relationships in the presence of conflicting concrete details, or as stemming from a relatively more complex or artistic approach to the mapping problem. Probably the second interpretation will find more favor. In any case, these results indicate that basic analogical ability is well developed in preschool children.

However, although these results run contrary to the notion that ability to deal with analogical relationships appears late in development after basic language skills have been acquired, these results are still compatible with Chukovsky's (1968, p. 7) position that the child of 2-5 years is a "linguistic genius", whose creative approach to language fades and disappears by the age of around 7 or 8 years.

Table 1. Mean numbers of reversals in orientation task, Experiment 1.

Orientation	Preschool	First Grade	Adult
Upright			
Connected	1.0	.1	.3
Discrete	1.5	.6	1.0
Upside Down			
Connected	.3	.3	.4
Discrete	1.3	.7	1.6
Horizontal			
Connected	.3	.4	.9
Discrete	.8	1.5	1.1
Mean	.87	.60	.88

Table 2. Mean numbers of ties and reversals in local features task, Experiment 1.

	Preschool	First-grade	Adult
Eyes above mouth	.1	.1	.4
Eyes same level as mouth	.1	0	.7
Eyes below mouth	.2	0	.4
Mean	.13	.03	.5

Table 3. Mean numbers of reversals in orientation task, Experiment 2.

Orientation	7 - 9 years	Adult
Upright		
Connected	.13	.25
Discrete	.38	.63
Upside Down		
Connected	0	.13
Discrete	.5	.75
Horizontal		
Connected	.13	0
Discrete	.38	.38
Mean	.25	.36

Table 4. Mean numbers of ties and reversals in local-features task, Experiment 2.

Configuration	7 - 9 years	Adult
Eyes above mouth		
Connected	0	0
Discrete	.38	.5
Eyes below mouth		
Connected	0	0
Discrete	.25	.88
Eyes same level as mouth		
Connected	0	0
Discrete	1.0	1.63
Mean	.27	.50

In order to test this notion, older children and adults were compared on the same basic tasks.

Experiment 2

Method

Subjects The subjects were eight children aged 7-9 and eight students at the University of Washington.

Procedure The tasks and procedures were basically those of Experiment 1, with a few minor changes. The first change was that the tasks were explained more thoroughly at the outset, to minimize differences in interpretation of the task. In the Orientation task, subjects were told that the feet should be placed near the roots, regardless of the orientation of the tree. In the Local-features task, subjects were told that they should put in the face-parts where they belonged, regardless of the details present in the mountain. The second change was that the Local-features task was expanded somewhat. Five face parts -- eyebrows, eyes, nose, mouth, and chin -- were used, and the mappings were performed in both discrete and connected mode. The third change was that the pictures used were somewhat more uniform than in the first experiment. In Experiment 1, the details of the pictured objects varied, although the heights and overall proportions were kept the same. For Experiment 2, all trees and mountains were traced from a standard tree or mountain, so that the pictures were almost identical.

Materials There were 44 pictures: 21 trees, 18 mountains, and 5 filler pictures of animals. As in Experiment 1, order was random.

Results The results are shown in Tables 3 and 4. There was no significant effect of age in either task, although children appear to make fewer reversals than adults. Mode of mapping was significant in both tasks: subjects made more reversals when mapping each term onto a separate picture than when mapping a whole set of terms onto one picture. ($F(1,14) = 19.79$, $p<.01$ for the Orientation tasks; $F(1,14) = 21.28$, $p<.01$ for the Local-features task). In the Local-features task, the effects of configuration and of the interaction of configuration with mode of mapping were also significant ($F(2,28) = 4.74$, $p<.05$, and $F(2,28) = 4.71$, $p<.05$, respectively.) These effects reflect the fact that, as in the first experiment, subjects made most errors on the configuration in which eyes and mouth were on the same level, particularly in discrete mode. There were no other significant effects.

Discussion Children aged 7-9 performed at least as well as adults. Thus the curvilinear pattern does not hold for this task. In fact, every age group tested showed considerable ability to consistently map the relations among human body parts onto other objects. There is no developmental trend at all.

How can these results be reconciled with the developmental improvement found in other studies? I offer the following resolution: The ability to perceive similar relationships between different entities is present early in language development, as can be seen in children's early

application of relational predicates (eg "more") to different objects, (eg cookies, toys, etc). Such usages are evidence that young children possess analogical ability. However more is required before this skill can be used appropriately by adult standards. The application of a relationship from one domain to another domain is analogical regardless of whether the result is a correct usage, eg "the foot of the table", or a novel usage, eg "the foot of the ice cream", and regardless of the child's knowledge of its correctness. However, an element of deliberate control is usually considered important in true metaphor. Children must learn the non-metaphorical meanings of words before they can deliberately choose to use a word in a novel manner. They also must learn the conversational rules governing when figurative speech is appropriate and how it is signalled, and they must learn conceptual systems more abstract than the physical relations considered in this study before they can accurately analogize about them. Finally, to be considered an artistic speaker, a child must learn to avoid familiar comparisons and must be able to simultaneously map many different relationships. This last is the only developmental change which seems to me basic to the central analogical process. Most of the developmental changes in use of metaphor stem from changes in general language proficiency.

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